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<p>(54) Title: REDUCTION OF SULPHUR CONTENT IN FCC-NAPHTHA</p> <p>(57) Abstract</p> <p>The present invention comprises a composition for reducing the sulphur content in a hydrocarbon composition, wherein the composition comprises a hydrotalcite material, which has been impregnated with a Lewis acid, and optionally an FCC-catalyst. The hydrotalcite material impregnated with the Lewis acid has been added as a separate component, or incorporated in the matrix of the FCC-catalyst. The Lewis acid is selected from the group comprising elements and compounds of the transition metals, and preferably Zn, Cu, Ni, Co, Fe and Mn, most preferably Zn. Further, the Lewis acid may also be selected from the group comprising elements and compounds of the lanthanides and actinides. The present invention also comprises a method for reducing the sulphur content in a hydrocarbon composition. A method for reducing the sulphur content in a hydrocarbon composition, which is to be cracked, is also described. Further, the use of a composition comprising a hydrotalcite material, which has been impregnated with a Lewis acid and optionally, mixed with an FCC-catalyst, is also included.</p>		

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Reduction of sulphur content in FCC-naphtha.

The present invention comprises a composition and a method for reducing the sulphur content in a hydrocarbon composition. Further, the invention comprises a method for reducing the sulphur content in a hydrocarbon composition, which is to be cracked. The invention also comprises the use of a composition for reducing the sulphur content in a hydrocarbon composition.

Legislation regarding environmental aspects sets a limit for the sulphur content in petrol. Petrol is a direct contributor to SO_x -effluents, and is also poisoning car catalysts at low temperatures (low temperature activity). The main sulphur contributor in petrol is FCC-naphtha (fluid catalytic cracking-naphtha), and efforts to obtain an effective reduction of the sulphur content must therefore be based on said petrol component.

It is also known to reduce the sulphur content in FCC-naphtha by hydrogenation of a flow of FCC-feed or of FCC-naphtha. Both methods require high investment costs and are expensive to operate. A third method for reducing the sulphur content in FCC-naphtha is to lower the end boiling point of FCC-naphtha since the main part of the sulphur component in FCC-naphtha exist in the heavy fraction. A disadvantage concerning the latter method is that some of the components in FCC-naphtha having highest octane number are also present in the heavy fraction. A lowering of the end boiling point will also reduce the octane number in addition to reducing the yield of naphtha.

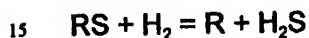
WO-86/06090 describes a method for oxidation of SO_2 into SO_3 wherein a hydrocarbon composition is contacted with a material existing of a spinel composition including an alkaline earth metal, an aluminium component and one or several metals, including zinc. Reducing the sulphur content in FCC-naphtha is not mentioned in WO-86/06090.

From WO-87/06157 is it further known a composition comprising a spinel, preferably a magnesium-aluminium-containing spinel, which has been impregnated with one or several metals to promote oxidation of SO_2 to SO_3 . The metals are preferably selected from the group consisting of IB, IIB and/or the group of platinum metals.

Prior art mentioned above comprises compositions for oxidation of SO_2 into SO_3 in the regenerator of a catalytic cracker. Regarding this process, it is not desirable with SO_x – effluents from environmental aspects, and effluents of sulphur made of H_2S is more convenient for most refineries, wherein H_2S is converted into elementary sulphur. A composition for reducing SO_x –effluents, in most cases a metal oxide (MO), possesses the following effect:

- oxidizing SO_2 into SO_3 in the regenerator $2 \text{SO}_2 + \text{O}_2 = 2\text{SO}_3$
- reacting with SO_3 and create a metal sulphate $\text{SO}_3 + \text{MO} = \text{MSO}_4$
- submit sulphur as H_2S in the cracker, and create the oxide state of the metal $\text{MSO}_4 + 4\text{H}_2 = \text{MO} + \text{H}_2\text{S} + 3\text{H}_2\text{O}$

The prior art mentioned above does not refer to reduction of the sulphur content in a hydrocarbon composition or FCC-naphtha as in the present invention. Reduction of the sulphur content in a hydrocarbon composition or in a hydrocarbon composition which is cracked, is obtained according to the composition of the present invention, and described according to the following reaction:



According to the above mentioned, the chemistry concerning the reduction of the SO_x –effluent and the reduction of the sulphur content in FCC-naphtha is different. A composition, which reduces SO_x –effluent, can not be expected to reduce the sulphur content in a hydrocarbon composition or in a hydrocarbon composition which is cracked catalytic.

A composition and method for reducing the sulphur content in FCC-naphtha, which uses a special catalyst or composition, added a known FCC-catalyst comprising a zeolite and a matrix, is known. A catalyst or composition as such which reduces the sulphur content in FCC-naphtha, is described by Wormsbecher et al. in EP-A1- 609971, wherein a composition comprises a Lewis acid deposited on an aluminium oxide carrier. EP-A1- 609971 also describes that

the Lewis acid may comprise components and compounds including Zn, Cu, Ni, Ag, Cd, Lu, Su, Hg, Tl, Pb, Bi, B, Al and Ga deposited at aluminium oxide. The above mentioned patent application also refer to compositions which comprises aluminium oxide and spinel which may be added to catalytic cracking catalysts to
5 reduce the SO_x -effluent during oxidation and regeneration of the FCC-catalyst. So far, the industry has not developed compositions comprising catalytic splitting catalysts for reducing the sulphur content in products as petrol and diesel.

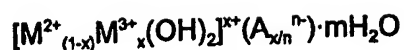
EP 798362, Ziebarth et. al describes TiO_2 -containing compositions which reduce the sulphur content of the product flow from a catalytic cracking-catalyst.
10 The present invention comprises a composition for reducing the sulphur content of a hydrocarbon composition and of a catalytic cracked hydrocarbon composition wherein the composition comprises a carrier made of a hydrotalcite material, different from i.a. Wormsbecher et al and Ziebarth et al.

The present invention provides a composition for reducing the sulphur
15 content in a hydrocarbon composition wherein said composition comprises a hydrotalcite material which is impregnated with a Lewis acid, and optionally a FCC-catalyst. The hydrotalcite material impregnated with the Lewis acid has been be added as a separate component, or incorporated in the matrix of the FCC-catalyst. Said Lewis acid is selected from the group comprising elements and
20 compounds of the transition metals, preferably Zn, Cu, Ni, Co, Fe and Mn, most preferably Zn. The Lewis acid is also selected from the group comprising elements and compounds of the lanthanides or the actinides. Preferably, the composition of the present invention is promoted with a hydrogen transfer promoter, preferably made of Pt. Further, the present invention provides a method for reducing the
25 sulphur content in a hydrocarbon composition, wherein said composition is contacted with a composition comprising a hydrotalcite material impregnated with a Lewis acid. A method for reducing the sulphur content in a hydrocarbon composition which is to be cracked is also disclosed, in which said hydrocarbon composition is contacted with a composition comprising a hydrotalcite material
30 which is impregnated with a Lewis acid and a FCC-catalyst. Said Lewis acid is selected from group comprising elements and compounds of the transition metals, preferably Zn, Cu, Ni, Co, Fe and Mn, most preferably Zn. The Lewis acid is also

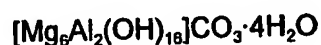
selected from group comprising elements and compounds of the lanthanides and the actinides. Said hydrotalcite material is preferably promoted with a hydrogen transfer promoter, preferably made of Pt. According to the method for reducing the sulphur content in a hydrocarbon composition which is to be cracked, said

5 hydrotalcite material impregnated with the Lewis acid has been added as a separate component, or has been incorporated in the matrix of the FCC-catalyst. Further, the use of a composition comprising a hydrotalcite material, which has been impregnated with a Lewis acid, and optionally mixed with a FCC-catalyst for reducing the sulphur content in a hydrocarbon composition, is also disclosed. The
10 Lewis acid is selected from group comprising elements and compounds of the transition metals, and preferably Zn, Cu, Ni, Co, Fe and Mn, most preferably Zn. Further said Lewis acid is selected from the group comprising elements and compounds of the lanthanides and the actinides. It is preferred using a composition promoted with a hydrogen transfer promoter, preferably made of Pt.
15 Use according to the present invention is preferably a hydrocarbon composition which is a cracked hydrocarbon composition made of FCC-naphtha. Further on, use of a hydrotalcite material impregnated with a Lewis acid is enclosed, in which said hydrotalcite material has been added as a separate component, or has been incorporated in the matrix of the FCC-catalyst.

20 Several compositions, mainly metals impregnated on different kinds of carriers than aluminium oxide, are tested. Said carriers comprise i.a. silicon oxide, titanium oxide and zirconium oxide. According to the present invention, said Lewis acid impregnated hydrotalcite material is found to reduce the sulphur content in a hydrocarbon composition considerably, primarily in a hydrocarbon composition,
25 which is to be FCC cracked. The process for preparing said hydrotalcite material, henceforth referred to as Mg (Al)O, is described in WO 94/29021 which is enclosed by reference. The hydrotalcite material possesses a particular high stability during steaming/steam treatment at high temperatures, and may be used as a carrier in catalytic processes. Cavani, F., et al, Catalysis Today, 11 (1991)
30 173, describes hydrotalsite and hydrotalsite like materials which is minerals or chemical components which has been expressed according to the following formula:



where x, which generally is between 0.1 and 0.5, M^{2+} , is a divalent metal ion
 5 (Mg^{2+}), M^{3+} a trivalent metal ion (Al^{3+}), while A^{n-} is one or several anions as e.g. carbonate or borate. A typical hydrotalcite is as follows:



10 which also represent the natural occurring hydrotalcite mineral. The proportion may be varied according to the ratio between Mg and Al, wherein both the metals may be replaced by other di- or tri-valent metals, and carbonate has been replaced by other anions. Calcination of $[Mg_3Al(OH)_8]CO_3 \cdot xH_2O$ at temperatures in the range of from 400-1000°C makes a mixed oxide, expressed as $Mg(Al)O$.
 15 $Mg(Al)O$ consists substantially of a MgO structure where some of the Mg-atoms are replaced by Al. Calcination increase the surface by a size of from 45 m²/g close up to 200 m²/g. The surface is also highly hydrothermal stable, and is reduced little by steaming.

Hydrotalcite material itself does not possess enough capacity to reduce
 20 sulphur, and impregnation is therefore required. It is observed that impregnation of a hydrotalcite material with a Lewis acid is reducing the sulphur content in a hydrocarbon composition and in a hydrocarbon composition, which shall be FCC cracked. The Lewis acid may contain components with several metals. It is most preferably to use a Lewis acid including compounds of zinc for reducing the
 25 sulphur content in FCC-naphtha. The accessibility of hydrogen is important when reducing the sulphur content in FCC-naphtha since the sulphur is removed in the form of H_2S . It is observed that addition of a hydrogen transfer promoter to a sulphur reducing composition of the present invention, increase the accessibility of hydrogen, which thereafter is reducing the sulphur content. Hydrogen transfer
 30 promoters of the group of the platinum metals is preferred, preferably platinum (Pt). It is observed that said composition also is reducing the sulphur content in LCO (light cycle oil) and HCO (heavy cycle oil) from a catalytic cracker.

The catalytic cracking is occurring in conventional FCC- units, more precisely comprising a reactor and a regenerator, where the reaction temperature is in the range of from 400-700°C, and the regenerating temperature is in the range of from 500-850°C. The FCC-catalyst is circulating in FCC-units in a continuous reacting/regenerating process. The hydrocarbon composition, which is to be added to the FCC-unity, comprises gas oils and other heavy hydrocarbons with boiling point from about 300°C and higher. Said gas oils and other heavy hydrocarbons possess generally a sulphur content in the range from 0,1 - 2,5 weight percentage.

The FCC-catalyst is preferably made of powder, and generally possesses an average particle size in the range of from 50-100µm, and a bulk density in the range of from 0,4-0,9 kg/l. If the composition described in the present invention is made of powder and further is mixed mechanically with the FCC-catalyst, is it preferred that the particle size, the density and mechanical strength of said composition and said FCC-catalyst have the same size.

The present invention comprises a new composition for reducing the sulphur content in a hydrocarbon composition and in a catalytic cracked hydrocarbon composition. The efficiency of this new composition is given in the following examples. Example 1 indicates a composition described by Wormcbecher et al., EP 609971-A1, zinc at aluminium oxide (Al_2O_3). This composition described in EP 609971 was made as a comparative example, and reduction of the sulphur content is shown in figure 1. Example 2 describes a composition based on zinc impregnated at said hydrotalcite material, and in figure 2 a hydrotalcite material is compared with prior art ($\text{Zn}/\text{Al}_2\text{O}_3$). Example 3 gives that a hydrotalcite material itself does not possess an effect reducing the sulphur content in FCC-naphtha. Example 4 shows the effect of a composition which is promoted for reducing the sulphur content (Pt promoted on a $\text{Zn}/\text{Mg}(\text{Al})\text{O}$ - composition).

Naphtha, which is to be created by catalytic cracking, contains different sulphur containing components, i.e. mercaptans, thiophenes, thiophenols and benzothiophenes. The composition of the present invention possesses different reducing effect on the sulphur containing components, which is created. Sulphur

reduction is most effective to mercaptanes, but also the content of thiophenes and thiophenols is reduced, as indicated in detail in example 5, table 1 and 2. In example 6, an analysis of the sulphur content in the LCO- and the HCO-fractions is performed. The results are shown in figure 5 and 6.

5

The figures 1-6 describe the following effects of the present invention:

Figure 1: Effect of $\text{Zn}/\text{Al}_2\text{O}_3$ on the sulphur content in FCC-naphtha.

Figure 2: Effect of $\text{Zn}/\text{Mg}(\text{Al})\text{O}$ on the sulphur content in FCC-naphtha.

Figure 3: Effect of $\text{Mg}(\text{Al})\text{O}$ on the sulphur content in FCC-naphtha.

10 Figure 4: Effect of Pt on $\text{Zn}/\text{Mg}(\text{Al})\text{O}$ on the sulphur content in FCC-naphtha.

Figure 5: Effect of $\text{Zn}/\text{Mg}(\text{Al})\text{O}$ and $\text{Pt}/\text{Zn}/\text{Mg}(\text{Al})\text{O}$ on the sulphur content in LCO.

Figure 6: Effect of $\text{Zn}/\text{Mg}(\text{Al})\text{O}$ and $\text{Pt}/\text{Zn}/\text{Mg}(\text{Al})\text{O}$ on the sulphur content in HCO.

Example 1:

15

A composition of $\text{Zn}/\text{Al}_2\text{O}_3$ was prepared by impregnating 10 wt% zinc on γ - Al_2O_3 by incipient wetness method. A commercial available FCC catalyst was divided in two parts. One of the parts was mixed with 10 wt% of the $\text{Zn}/\text{Al}_2\text{O}_3$ -composition. Both of the samples was tested by MAT (Micro Activity Test) at the following conditions:

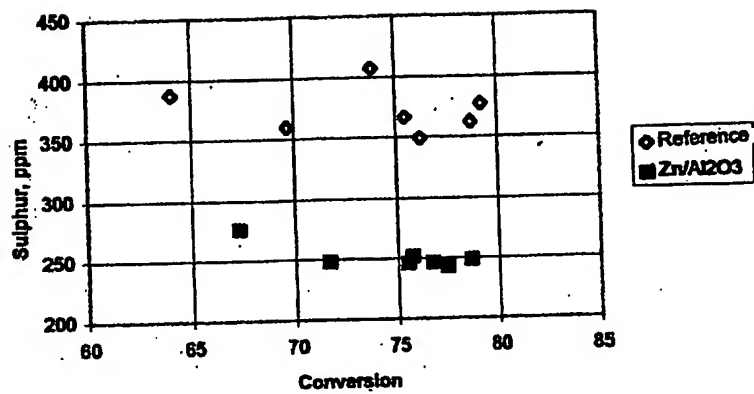
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Reacting temperature: 510°C

Injection time: 30 s

Feed: Atmospheric distillation residue from the North Sea

The sulphur content of the naphtha fraction in the experiments was set at AED (Atomic Emission Detector), and the results are given in figure 1. The catalyst test which was mixed with 10 wt% of the $\text{Zn}/\text{Al}_2\text{O}_3$ composition, gave a
25 reduction of the sulphur content in the FCC-naphtha fraction in the range of 15% compared to the reference test. The reference test or the reference catalyst is a FCC-catalyst without interference of other components or compositions.



5

10 Figure 1. Effect of Zn/Al₂O₃ on the sulphur content in FCC-naphtha.

Example 2:

A composition was prepared by impregnating 10 wt% zinc at Mg(Al)O by incipient wetness method. 10 wt% of the composition was mixed with the same commercial catalyst of example 1, and tested by MAT (Micro Activity Test) at the same conditions as given in example 1.

Figure 2 gives the results from this test (example 2) compared with the results from example 1 (Zn/Al₂O₃). It is given in the figure that the new composition of Zn/Mg(Al)O possesses the same reducing capacity of sulphur as Zn/Al₂O₃.

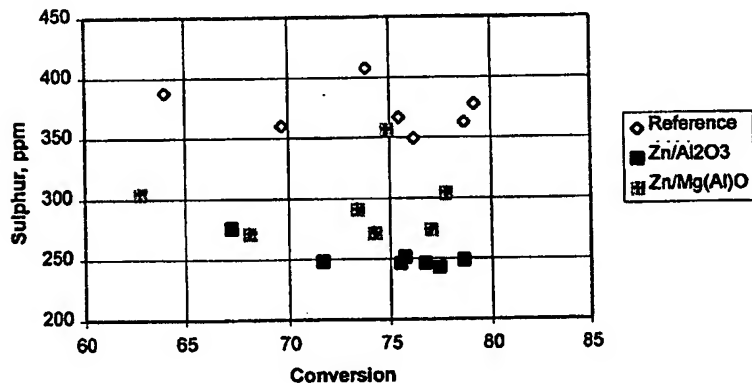


Figure 2. Effect of Zn/Mg(Al)O on the sulphur content in FCC-naphtha

Example 3:

10 wt% of the hydrotalcite material was mixed with a commercial catalyst, and tested in MAT at the conditions given in example 1 and 2.

Figure 3 gives the results from this test compared to Zn/Mg(Al)O prepared according to example 2, and with the reference test. It appears from the figure that the hydrotalcite material does not possess significant effect on the sulphur content in FCC-naphtha without addition of a metal.

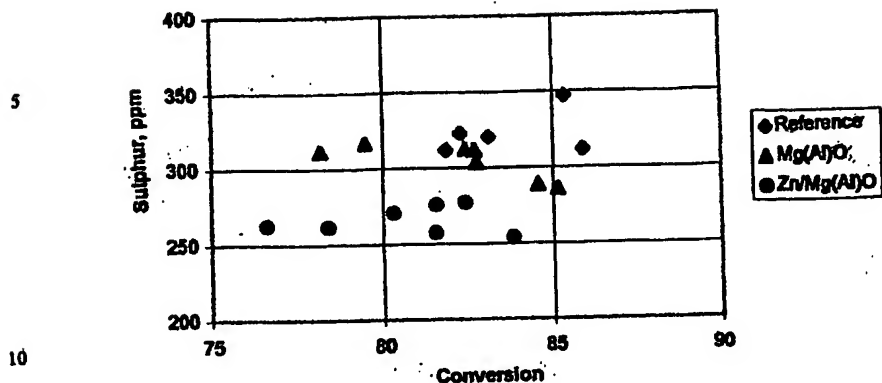


Figure 3. Effect of Mg(Al)O on the sulphur content in FCC-naphtha.

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Example 4:

0,3 wt% Pt was added to the Zn/Mg(Al)O-composition described in example 2, by promoting platinum at the composition by incipient wetness method. 10wt% of the Pt-promoted composition was mixed with the same commercial FCC-catalyst as given in example 3.

20 The results of this test were compared with the results of example 2, which is given in figure 4. It appears from the figure that the Pt-promoted composition possesses a somewhat greater capacity for reducing the sulphur content than corresponding composition without Pt.

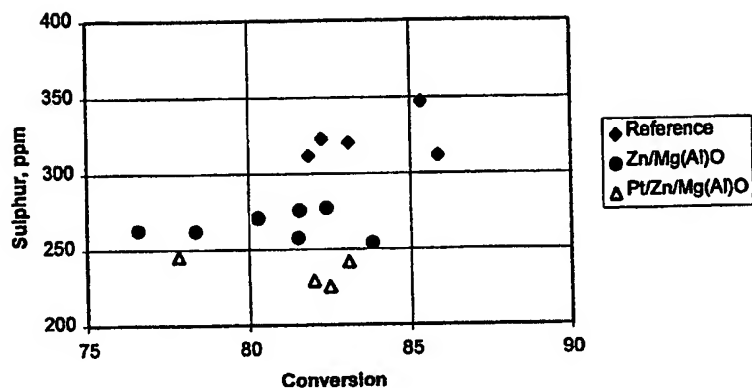


Figure 4. Effect of Pt/Zn/Mg(Al)O on the sulphur content in FCC-naphtha.

Example 5:

Each single sulphur component is detected by AED. The table 1 gives percentage reduction of the different sulphur compounds which is created in the naphtha fraction by catalytic cracking compared to the reference catalyst (FCC-catalyst without addition of other components). The results of Zn/Mg(Al)O is given from the test described in example 2, while the results of Pt/Zn/Mg(Al)O is given from the test described in example 4. The figures of table 1 are interpolated and compared at constant conversion (80%).

Compounds including sulphur	% Reducing Zn/Mg(Al)O	Pt/Zn/Mg(Al)O
Mercaptans	89	82
Thiophenes	33	26
C ₁ -thiophenes	21	11
C ₂ -thiophenes	14	17
C ₃ -thiophenes /thiophenes	23	24
C ₄ -thiophenes/ C ₁ -thiophenols	90	21
Tetrahydrothiophene	21	43
Benzothiophene	-12	23
Total content of sulphur in FCC-naphtha	17	26
Total content of sulphur in FCC-naphtha minus benzothiophene	34	28

Table 2 gives the results of the MAT- experiments of the composition of Zn/Mg(Al)O (example 2), third column.

Compounds including sulphur	Reference	Zn/Mg(Al)O (example 2)
Mercaptans	22	2
Thiophene	40	28
C ₁ -thiophenes	62	49
C ₂ -thiophenes	40	34
C ₃ -thiophenes /thiophenols	17	13
C ₄ -thiophenes/ C ₁ -thiophenols	7	1
Tetrahydrothiophene	8	6
Benzothiophene	118	132
Total content of sulphur in FCC-naphtha	313	266

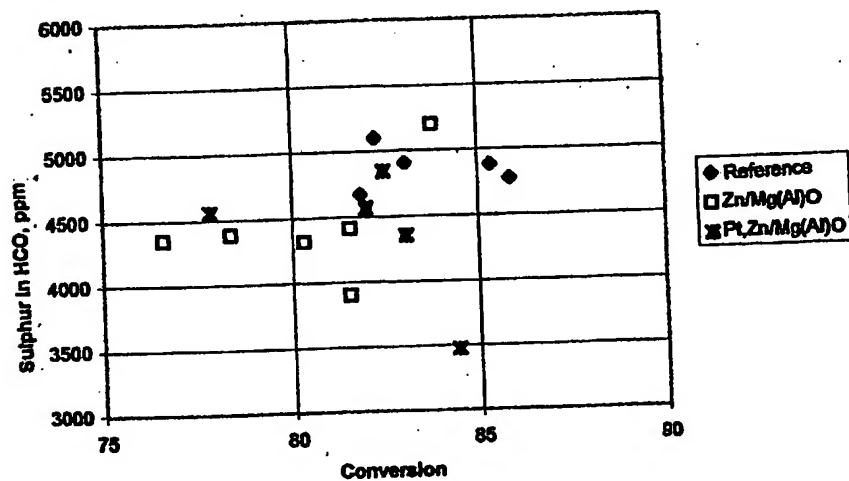
Example 6:

The analysis of the sulphur content in LCO- and HCO-fraction of the test described in example 4 was also carried out. The results of this analysis are given in figure 5 and 6. The sulphur content of these fractions was also reduced, as given in the figures.

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Figure 5. Effect of Zn/Mg(Al)O and Pt/Zn/Mg(Al)O of the sulphur content in LCO

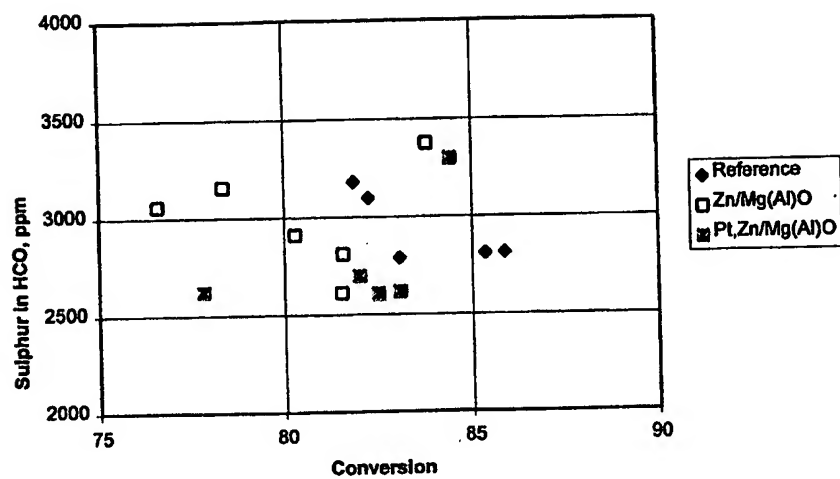


Figure 6. Effect of Zn/Mg(Al)O and Pt,Zn/Mg(Al)O of the sulphur content in HCO

Claims

- 1) Composition for reducing the sulphur content of a hydrocarbon composition,
5 wherein that said composition comprises a hydrotalcite material which has been impregnated with a Lewis acid and optionally a FCC-catalyst.
- 2) Composition according to claim 1, wherein the hydrotalcite material impregnated with the Lewis acid has been added as a separate component.
- 10 3) Composition according to claim 1, wherein the hydrotalcite material impregnated with the Lewis acid has been incorporated in the matrix of the FCC-catalyst.
- 15 4) Composition according to the claims 1-3, wherein said Lewis acid is selected from the group comprising elements and compounds of the transition metals, and preferably Zn, Cu, Ni, Co, Fe and Mn, most preferably Zn.
- 20 5) Composition according to the claims 1-4, wherein said Lewis acid is selected from the group comprising elements and compounds of the lanthanides or the actinides.
- 6) Composition according to the claims 1-5, wherein said composition has been promoted with a hydrogen transfer promoter.
- 25 7) Composition according to claim 6, wherein said hydrogen transfer promoter preferably is made of Pt.
- 8) Method for reducing the sulphur content in a hydrocarbon composition, wherein
30 said hydrocarbon composition is contacted with a composition comprising a hydrotalcite material impregnated with a Lewis acid.

- 9) Method for reducing the sulphur content of a hydrocarbon composition which is to be cracked, wherein said hydrocarbon composition is contacted with a composition comprising a hydrotalcite material which has been impregnated with a Lewis acid and a FCC-catalyst.
- 5 10) Method according to the claims 8-9, wherein said Lewis acid is selected from the group comprising elements and compounds of the transition metals, and preferably Zn, Cu, Ni, Co, Fe and Mn, and most preferably Zn.
- 10 11) Method according to the claims 8-10, wherein said Lewis acid is selected from the group comprising elements and compounds of the lanthanides or the actinides.
- 12) Method according to the claims 8-11, wherein said composition has been
15 promoted with a hydrogen transfer promoter.
- 13) Method according to claim 12, wherein said hydrogen transfer promoter preferably is made of Pt.
- 20 14) Method according to claim 9, wherein the hydrotalcite material impregnated with the Lewis acid has been added as a separate component.
- 15) Method according to claim 9, wherein said hydrotalcite material impregnated with the Lewis acid has been incorporated in the matrix of the FCC-catalyst.
- 25 16) Use of a composition comprising a hydrotalcite material, which has been impregnated with a Lewis acid and optionally mixed with a FCC-catalyst, for reducing the sulphur content in a hydrocarbon composition.
- 30 17) Use according to the claim 16, wherein said Lewis acid is selected from the group comprising elements and compounds of the transition metals, and preferably Zn, Cu, Ni, Co, Fe and Mn, most preferably Zn.

- 18) Use according to the claims 16-17, wherein said Lewis acid is selected from the group comprising elements and compounds of the lanthanides or the actinides.
- 5 19) Use according to the claims 16-18, wherein said composition has been promoted with a hydrogen transfer promoter.
- 20) Use according to the claims 16-19, wherein said hydrogen transfer promoter
10 preferably is made of Pt.
- 21) Use according to the claims 16-20, wherein said hydrocarbon composition is a cracked hydrocarbon composition made of FCC-naphtha.
- 15 22) Use according to the claims 16-21, wherein the hydrotalcite material impregnated with the Lewis acid has been added as a separate component.
- 23) Use according to the claims 16-22, wherein the hydrotalcite material impregnated with the Lewis acid has been incorporate in the matrix of the FCC-
20 catalyst.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO 99/00087

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C10G 25/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C10G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9748480 A1 (CONTRACT MATERIALS PROCESSING, INC.), 24 December 1997 (24.12.97), page 6, line 15 - line 23; page 7, line 21 - line 25; page 8, line 5 - line 20, and claim 3 --	1-23
X	US 5441630 A (EUGENE P.-S. DAI ET AL), 15 August 1995 (15.08.95), column 3, line 15 - line 32; the table in column 4 and column 6, line 20 --	1-23
A	EP 0609971 A1 (W.R. GRACE & CO.-CONN.), 10 August 1994 (10.08.94) -- -----	1-23

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Information on patent family members

01/06/99

International application No.

PCT/NO 99/00087

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